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THE SEARCH FOR OPTIMUM SOLUTIONS FOR MELTING INSULATOR GLASS

N. Ya. Gusak,[1] A. I. Postoronko,[1] and V. F. Gaivoronskii[1]

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The effect of the temperature conditions of melting and the design features of the glass melting furnaces on the increase in the specific removal of glass melt in processing quenched insulating parts of high-voltage suspension insulators is demonstrated. Designs are proposed for glass melting furnaces and glass melting temperature regimes whose use will increase the economy of manufacturing insulators.

High-quality glass melt is required for manufacturing and quenching the glass insulating parts of high-voltage suspension insulators which have a complex shape and thickness nonuniformity (Fig. 1). The degree of homogeneity of the glass, determined by centrifugation of glass powder mixed with organic liquids, should not exceed 1.8°C. The glass melt entering for processing must be uniform and contain no undissolved silica grains.

These requirements were basically satisfied by reducing the specific removal of glass melt to 400 kg/m^2 a day from the surface of the melting part of the furnace for 45% planned losses in processing, which significantly increased the power consumption and cost of the insulators. Increasing the specific removal of glass melt checked any increase in destroyed insulating parts in quenching and thermal control in the furnace in positive thermal shock with a 370°C temperature drop and a decrease in the reliability of the insulating parts and insulators.

A petrographic analysis of the causes of fracture of insulating parts in quenching and positive thermal shock showed that undissolved grains of silica were present in the fracture centers. The published data [1] and studies of glass melting and processing of insulating parts at L'vov Insulator Factory and South Ural Fittings-Insulator Factory indicate flow of the glass melt through the quellpoint and an increase in its upper layers enriched with silica into the neck.

For this reason, the increase in losses in quenching and the decrease in the reliability of both the quenched insulating parts of suspension insulators and annealed pin insulators can be attributed to the fact that the possibility of flow of the glass melt through the quellpoint and the increase in the upper layers into the neck increases. This is also indicated by the decrease in the electric strength of the insulating parts and insulators to values below the standardized values both in mass tests of insulators during production for the effect of a continuous stream of sparks not changing to an arc for 4 min and in acceptance tests of lots of insulators in determining tolerance of standardized breakdown voltage of 130 kV by their breakdown in transformer oil.

Since the results of chemical analyses confirmed the correspondence of the glass to the given composition, the decrease in the breakdown electric strength of insulators can also be explained by their thermal past — the state of the structure of the glass that affects its conductivity. O. V. Mazurin also advanced hypotheses concerning the thermal histry of glass on the conductivity [2].

For this reason, to improve the glass melting conditions and ensure entry of the ripe glass melt for processing, it was suggested that the maximum temperature zone in glass melting furnaces be extended to the production side, the temperature drop of the maximum and at the neck be decreased as much as the density of the shield lining and temperature in the production part of the furnace would allow.

The temperature curves in an alkali glass melting furnace are shown in Fig. 2*a*. The curves were plotted with the results of reading thermocouples installed in the side walls of the flame space of the furnace between burners and in the production part — in the roof.

Implementing the proposed solutions increased the specific output of quality glass melt to 450 kg/m^2 a day and reduced losses in production to 40% by increasing the duration of high-temperature glass melting and decreasing the backflow rate, which reduced the probability of flow through the

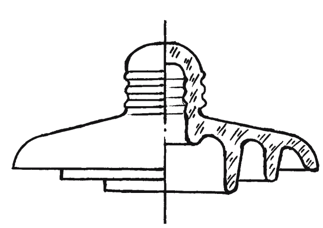

Fig. 1. Insulating glass part of a high-voltage suspension insulator.

[1] Scientific-Research Institute of High Voltages, Slavyansk, Ukraine; Ukrainian Engineering Education Academy, Slavyansk, Ukraine.

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quellpoint and an increase in the upper unneutralized layers of glass melt in the neck.

A further increase in the specific takeoff of the glass melt checked an increase in the inhomogeneity of the glass and losses in production due to the design of the glass melting furnaces used, especially for melting low-alkali glass where the maximum melting temperature is 1580 – 1600°C and the mirror surface of the glass melt was enriched with silica.

For this reason, a glass-melting furnace design with a surface area of 100 m^2 with no production tank part, proposed by Moscow State Special Design Institute, was used for melting low-alkali glass 13v in the glass insulator shop under construction at Slavyansk Fittings and Insulator Factory.

The furnace was initially started by the State Scientific-Research Institute of Glass with a classic temperature curve (Fig. 2*b*, curve *1*). However, in using this temperature curve, it was not possible to obtain a high yield of acceptable insulating parts in the furnace. The insulating parts fractured in the quenching machine and in positive thermal shock in the furnace.

As a result of petrographic analysis of the fracture centers of the insulating parts, it was found that they contained undissolved silica grains. Passage of a radioactive cobalt isotope from the batch and subsurface measurements of the temperature of the glass melt in the furnace showed that the upper high-temperature layers of glass melt containing undissolved silica are entrained into the feeders through the neck.

Based on the results obtained and experience in changing the temperature curve in the furnaces by the Scientific-Research Institute of High Voltages together with the State Scientific-Research Institute of Glass, the temperature curve was altered: the quellpoint was eliminated (see Fig. 2*b*, curve *2*). The maximum glass melting temperature in the furnace was extended to the inlet into the feeders, which increased the duration of high-temperature melting of the glass, provided for one basic convection current of the glass melt in the furnace, and eliminated any increase in the upper high-temperature layers of the glass melt enriched with silica into the feeder channels. The temperature of the glass melt entering the feeders decreased from 1370 to 1340°C, which significantly improved the conditions of operation of the channels and feeders.

The furnace design and decisions made on glass melting ensured an increase in specific production of glass melt to 500 kg/m^2 a day and a decrease in losses in production of insulating parts for the PS-70E insulator to 25 – 30%. A further increase in specific glass melt production was deterred by an increase in the inhomogeneity of the glass and production losses.

The design of the glass-melting furnace with no production part was not tested in production of insulating glass of alkaline composition. A glass-melting furnace design with a raised (by 250 mm) hearth in the clarification zone and before the neck, proposed by the Gusevsk branch of the SSRIG, was tested for melting this glass. However, positive results were not obtained. The glass melt entering for processing

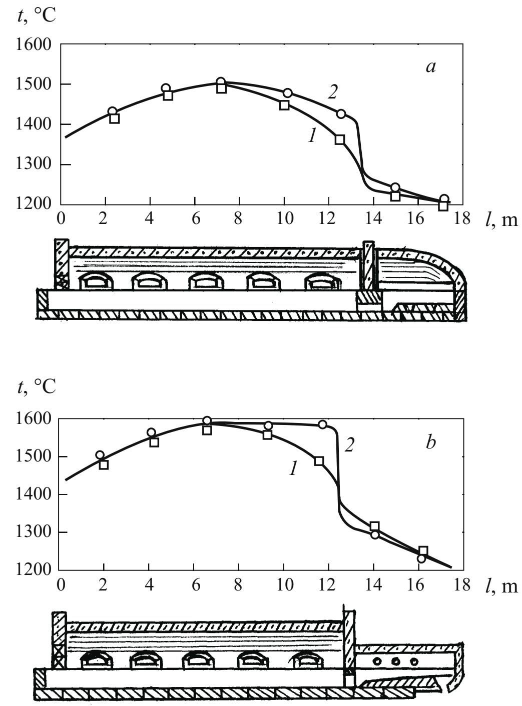

Fig. 2. Initial (*1*) and altered (*2*) temperature curves in alkali glass 7 (*a*) and low-alkali glass 13v (*b*) melting furnaces.

contained large and small bubbles. The furnace was stopped, and elevation of the hearth was eliminated.

In our opinion, the principles of designing glass-melting furnaces for production of sheet or bottle glass in which the specific removal of glass melt reach 1200 kg/m^2 a day and more and the glass melt quickly passes through the clarification zone were used in the furnace design solution.

The output of the machine line did not allow investigating the effect of specific removal of the glass melt on the quality of the glass.

Based on the above and accumulated experience in melting and production of insulating glass for production of quenched insulating parts of high-voltage suspension insulators, we believe that a glass-melting furnace design in which the production part of the furnace is not divided by a screen, but by a wall and is heated by an autonomous pair of burners should be used for melting them. It is also expedient to lower the bottom of the furnace at the neck and the neck by 300 mm. Such solutions will allow extending the maximum glass melting temperature zone to the neck, eliminating backflow in the furnace, and increasing the upper high-temperature layers of glass melt into the neck, which will make it possible to increase the output of the furnace, reduce losses in production, and decrease power consumption and the costs of the insulators.

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